CHAPTER 6

SAMPLE APPLICATIONS: THE INDIVIDUAL LCCA

6-1. Introduction.

This chapter and Appendix A provide illustrative material on how to conduct and document economic studies for MCP designs, with emphasis on the individual LCCA. Five LCCAs are presented. The five were selected in part to cover the implementation of the four sets of criteria presented in chapter 2, and in part to provide guidelines for properly applying those criteria to the three principal types of design features/elements encountered by the MCP designer-i. e., mutually exclusive energy consuming elements (such as alternative HVAC systems), mutually exclusive non-energy-consuming elements (such as alternative pavement designs), and non-mutually-exclusive "add-on" type elements (such as solar-energy systems). Analyses conducted in accordance with the criteria for general economic studies (para 2-2) are presented in paragraphs 6-2 and 6-3–the first one for a non-energy-consuming design feature, and the second for an energy-consuming one. Paragraphs 6-4 and 6-5 contain analyses conducted in accordance with the criteria for special energy-conservations studies (para 2–3 and 2–4, dealing with non-renewable resources and renewable resources, respectively). An analysis conducted in accordance with the criteria for special studies for innovative/alternative wastewater treatment technology (para 2-5) is presented in paragraph 6.

a. Cost data. All simulated case histories presented in this chapter were developed in January 1982, and all utilize cost information that generally reflects market prices and cost-growth projections of that timeframe (see para 1-4).

b. Present worth calculations. In this manual, a separate PW calculation is made (and shown) for each alternative included in the LCCA. In actual practice, however, it will occasionally be much simpler to make the PW calculations only once, for all the alternatives in the LCCA. When this approach is used, a unit cost is assumed for each of the cost types in the LCCA (e.g., initial costs, annual M&R costs, annual electricity cost, annual natural gas cost, twelfth-year replacement cost, etc.), and the PW's corresponding to these costs are calculated. For any given cost type, the actual PW for any of the alternatives is simply the product of the magnitude of that particular cost for the alternative of interest and the PW determined from the unit cost calculations. The unit-cost approach is generally used in LCCAs with a number of alternatives (three or four or more), as in the LCCAs in paragraph 6-4 and 6-6, or in the typical LCCA conducted in support of a solar-sizing design study.

c. Documentation.

(1) For LCCAs in general. The principal components of the typical LCCA documentation are:

– Cover sheet (title page)
– Contents page
– Summary of LCCA results
– Data and calculation sheets for each alternative
  - Input data summary sheets
  - PW calculation sheets
  - Backup sheets

Backup sheets, which normally comprise the bulk of the documentation, are basically of the following three types:

– Sheets copied from published documents (which may or may not be included in the official design analysis documentation for the MCP project)—for example, the Environmental Protection Agency Manual 430/9-78-009, which served as the major source of data for the wastewater treatment facility LCCA (para 6-6).
– Sheets generated for the official design analysis documentation and included therein.
– Sheets generated specifically in support of the LCCA—for example, BLAST computer-run summary sheets, showing energy con-. sumption for the HVAC alternatives studied in paragraphs 6-3 and 6-4.

Backup sheets of the third type cited above normally are included directly in the documentation for the LCCA. Backup sheets of the first two types cited above, on the other hand, normally are included in the documentation by reference only (usually on the basis input data summary sheet).

(2) For LCCAs in this manual. The documentation for the LCCAs presented in this chapter can be found in appendix A. That documentation consists, for each LCCA, of the input data summary sheet and the PW calculation sheet for each alternative, followed by the summary sheet for the LCCA as a whole. (The other principal

components of the typical LCCA documentation cited above are not presented in appendix A because of practical considerations.)

6-2. Roadway/parking surface.

This LCCA is part of the economic study for a FY 84 project, involving the construction of a reserve training building in the Tidewater area of Virginia. The building is needed to provide training facilities for a 200-member reserve unit, and is estimated to cost $3,500,000. The LCCA for the roadway/parking surface provides a simple illustration of the use of the one-step PW calculation approach in applying the general economic study criteria of paragraph 2-2 to two mutually exclusive non-energy-consuming alternatives. In addition, it serves as an example of one type of LCCA that is likely to prove to be cost-effective, in that the study results may prove to be applicable to a number of different projects in the MCP (see para 2-2a(2)).

a Input data. The basic input data summary sheets for the two alternatives (see appendix A) reflect the fact that this LCCA is conducted in accordance with the provisions for general economic studies (HQDA criteria). Thus, the discount rate is 10 percent; the ABD is the actual date on which the study is performed (the DOS); and the midpoint of construction and the BOD are taken as the actual projected dates for these events. The 25-year projected life of the roadway determines the analysis period and the analysis end date—25 years after the BOD. All costs associated with each alternative are estimated as of the DOS and listed on the input data summary sheet for that alternative, along with the actual dates on which they will be incurred (based on the actual BOD) and the sources of the cost data. The costs and the times when they are incurred are depicted graphically on a cash flow diagram. According to the criteria for general economic studies, the initial procurement/construction cost is charged at the midpoint of construction. The M&R costs for each year are accumulated as a single annual lump sum and charged at the mid-point of the year in which they are incurred the first such cost is thus charged one-half year after BOD, on 1 January 1985.

b. Computations. The PW calculations (using the -one-step approach) are shown on the PW worksheets for the two alternatives (app A).

c. Summary. The results of the LCCA are summarized on the summary worksheet (app A). The results do not appear to be clearcut-i.e., they are neither clearly conclusive nor clearly inconclusive. In spite of this, an uncertainty assessment is not required, since the relative economic ranking of the two alternatives cannot be affected by the results of the assessment (para 2-2b(9))—i.e., alternative A gets the higher ranking in any case, either by the provisions of paragraph 2-2c(1) or 2-2c(2), whichever would turn out to be appropriate (if an uncertainty assessment were made). Accordingly, the designer elected alternative A for implementation.

6-3. HVAC system: conventional design.

This LCCA is part of the economic study for a FY 84 project–the Central Administration Building at the ABCDE Ammunition Plant, located in Mississippi. The building will contain approximately 70,000 square feet, and is expected to cost approximately $70 per square foot to construct. Occupancy is projected for January 1985. The LCCA illustrates the use of the conventional PW calculation approach in applying the general-economic-study criteria for paragraph 2-2 to two mutually exclusive energy-consuming alternatives. It also illustrates the use of the artificial net salvage value (in a sense, a “retention value” or “residual value”) in those cases where the alternatives have different economic lives and the economic life of the facility (or 25 years) is not an exact multiple of those economic lives. This LCCA represents the first step in the design of an energy-consuming element of a facility, utilizing criteria and procedures no different from those used in the design of a non-energy-consuming element. At this early design stage, the designer is primarily interested in identifying the best conventional design for the application at hand, without giving any consideration to extraordinary energy-saving design initiatives. Accordingly, the LCCA is governed by the provisions of paragraph 2-2 (as was the LCCA illustrated in para 6-2). Once the best conventional design is determined (for that particular design element and for all other key elements of the building), a baseline design is established, against which the potential cost effectiveness of various extraordinary energy-saving design initiatives may be measured. Typical LCCAs for energy-conservation applications are addressed in paragraphs 6-4 and 6-5.

a. Input data. Input data are determined and entered on the data summary sheets (app A). The facility life is projected to be well in excess of 25 years; however, the analysis period is taken to extend only 25 years beyond the BOD, in accordance with the provisions of paragraph *2-2b(3)(b).* All costs associated with each alternative are estimated and listed on the data summary sheet for that alternative, along with the times they will be incurred, and the sources of cost data. The net salvage value calculated for each alternative is listed as a negative cost to be incurred on the analysis end date. All costs are shown on the cash flow diagram for each alternative.

b. Computations. The net PWs for the two alternatives are here computed by the conventional approach (for no reason other than to provide an illustration of that approach). Initial procurement costs are charged at the midpoint of construction, which here is 2.5 years after the DOS and hence after the ABD. Other one-time costs are charged at the times they are expected to be incurred. Annual costs are charged at the middle of each year; the first such cost is incurred one-half year after the BOD, which is 3.5 years after the DOS/ABD. The PW of each cost is computed, and the net LCC for each alternative is obtained as shown on the PW worksheets (app A). The annual series equivalence factors were determined from table B-2. (Linear interpolation was used to interpolate between the tabulated data points.)

c. Summary. The results of the LCCA are summarized on the summary worksheet DA Form 5605-2-R (fig. A-13). The results are clearly conclusive; alternative A is ranked higher on the he basis of its lower net LCC and is used as the baseline conventional system in the LCCA of paragraph 6-4 below.

6-4. HVAC system: energy conservation.

This LCCA, like the one presented in paragraph 6-3, is part of the economic study for the Central Administration Building at the ABCDE Ammunition Plant, in Mississippi. As indicated in paragraph 6-3, once the most economical conventional HVAC design has been determined, the next step involves the conduct of a special energy study to determine if there are any extraordinary energy-saving designs that would be more economical (than the conventional design) for this particular application. It is this second step in the HVAC system design-the special energy study required by statute–that the LCCA presented in this paragraph addresses. There are four alternatives included in the LCCA—three different energy-saving designs, all based on the use of non-renewable energy resources, plus the most economical conventional design, determined from the results of the LCCA discussed in paragraph 6-3. The LCCA illustrates the use of the conventional PW calculation approach in applying the special FEMP criteria of paragraph 2-3 to these four HVAC-system alternatives.

a. Input data. The basis input data summary sheets for the four alternatives (app A) reflect the fact that this LCCA is conducted in accordance with the provisions for special directed studies on energy conservation (FEMP criteria). Thus, the discount rate is 7 percent; a 10 percent investment credit is applied to the initial costs of all alternatives; the end-of-year convention is used for annual recurring costs; and the timing of project events is artificial. The analysis base date is taken to be 1 July 1981, corresponding to the FEMP-prescribed base data in effect at the time the study was conducted. That data is also taken as the assumed BOD and the midpoint of construction (more specifically, as the date on which initial procurement/construction costs are charged). All post-BOD one-time costs are assumed to occur on the date on which they would have occurred if the BOD were actually 1 July 1981. Thus, for example, the fan replacement for alternative A is expected to occur 15 years after BOD. This replacement would actually occur on 1 January 2000, since the actual BOD is 1 January 1985. However, for the analysis, with an artificial BOD of 1 July 1981, it is assumed that the fan replacement would occur on 1 July 1996. Moreover, as per FEMP criteria, annually recurring costs are charged at the end of each year, beginning with 1 July 1982–one year after the artificial BOD of 1 July 1981. The analysis period–25 years-is assumed to begin on the ABD (1 July 1981) and end 25 years later, on 1 July 2006. All costs associated with each alternative (including the negative net salvage costs) are listed on its input data summary and included in the calculation of its net LCC. Differential escalation rates for the cost of fuel oil and electricity are those which were prescribed for the FEMP at the time the study was conducted, as indicated in paragraph 1-4. In accordance with HQDA (DAEN-ECE-G) guidance at the time of the study, these rates were determined from tabulated values for the Commercial Sector, published in 10 CFR 436A. The rates used are those for DOE Region 4, the appropriate region for a facility in Mississippi (app C). With regard to cost estimates, the preferred approach is to have all costs reflect market prices as of the ABD. If these costs are too difficult for the designer to obtain, the designer is permitted-as an approximation—to base all costs on the purchasing power of the dollar on the DOS, and to assume that this represents the purchasing power of the dollar on the ABD. In any case, when the designer elects to use this approximation, he or she must do so for *all costs.*

b. Computations. The present worths of the four alternatives are computed by the conventional approach and entered on PW worksheets (app A). This approach is used here to provide additional examples of its use, this time following the provision of paragraph 2-3 (FEMP criteria); the one-step approach would have given the same results. A 10 percent credit is applied to the initial investment cost of all alternatives. The effect of this credit is to reduce the extra initial investment cost of the energy-saving alternatives. The annual series equivalence factors were determined on the basis of linear interpolation between tabulated data points in table B-2. Note that the PW of conventional alternative A is recalculated here according to the FEMP criteria of paragraph 2-3; the resulting net LCC differs from that calculated in paragraph 6–3 using paragraph 2-2 criteria.

c. Summary. The results of the PW calculations are summarized on the LCCA summary sheet DA Form 5605-2-R (fig A-13). The four alternatives are ranked solely on the basis of net LCC—the alternative with the lowest net LCC receiving the highest economic ranking. The difference in net LCC between the highest-ranked alternative (alternative D) and the second highest-ranked alternative (alternative B) is about 1 percent, must less than the probable accuracy of the cost data involved in the analysis. Thus, these alternatives tie considered to be tied, and the designer must use his or her best judgment to select either alternative D or alternative B for implementation (para 2-3c). In this case, the designer selected alternative D because it is expected to consume less energy than alternative B.

6-5. Domestic water heating system: energy conservation (solar).

This LCCA, like those presented in paragraphs 6-3 and 6-4, is part of the economic study for the Central Administration Building at the ABCDE Ammunition Plant in Mississippi. Like the LCCA presented in paragraph 6-4, it is conducted as part of the special energy study for the project, to determine if there are any extraordinary energy-saving designs that would be more economical (than the best conventional design) for this particular application. Unlike that LCCA, however, the LCCA presented here deals with the domestic hot water (DHW) system, and the use of non-renewable energy resources—in the form of solar-energy-is specifically considered. Accordingly, this LCCA is considered to be responsive to the special statutory requirement on energy conservation for MCP facilities (as described in paragraph 2-4). It illustrates the use of the conventional PW calculation approach: for a design application in which the alternatives are not necessarily mutually exclusive (i.e., the solar-energy system cannot stand alone, but must have a conventional system as backup), and in applying the special FEMP criteria of paragraph 2-4 for the case of an incremental approach, where only incremental costs (i.e., cost differences) between two alternatives are considered. It also illustrates the special economic ranking calculations—savings-to-investment ratio and discounted payback period (SIR and DPP)–which may be required for certain types of energy-conservation applications (e.g., solar-energy systems).

a. Input data. The baseline alternative (alternative A) is the best conventional design-an electric DHW system (as determined from the results of an LCCA conducted earlier and not illustrated herein). The other alternative (alternative B) is a DHW system that consists of a solar-energy-based heating system and a conventional heating system for backup. The conventional system selected for backup is the alternative A electric heating system. In accordance with standard practice for the incremental-analysis approach, only the incremental costs—i.e., the cost differences between the alternative B combined system and the alternative A baseline system—are considered, and only these are listed on the single basic input data summary worksheet (app A). These are the extra costs (and/or cost savings) that are attributable to the solar-energy “add-on”. (The cost figures for each of the two alternatives considered in the typical incremental-analysis approach, from which the incremental costs are calculated, would be provided on the appropriate backup sheets in the LCCA documentation.) The basic input data summary worksheet reflects the fact that this LCCA is conducted in accordance with the provisions for special directed studies for energy conservation (FEMP), as was the LCCA presented in paragraph 6-4. The extensive discussion provided there on the application of the FEMP criteria—e.g., the use of a 7 percent discount rate, 10 percent investment credit, end-of-year convention for annually recurring costs, artificial timing for project events, 1 July 1981 ABD, differential escalation rates from 1982 CFR, etc. —is applicable to this LCCA as well. An analysis period of 25 years is used here, based on the assumption that the economic life of the facility will be at least 25 years. It is also assumed: that the economic lives of both the solar-energy system and the electric heating system are 25 years, and that the present worth (PW) of any net salvage value that would properly be claimed would be small enough to ignore. (It should be noted that, while both of these assumptions may be common, other views are equally common. The economic life of a typical solar-energy system is considered by many to be more on the order of 15-20 years, than 25 years, and the PW of the net salvage value of a typical solar-energy system is considered by many to be too large to ignore-i. e., based on the not uncommon assumption of a net salvage value for the solar "add-on", of as much as 20 percent or more of the initial investment cost, for the scrap value of copper tubing and other materials.) The incremental initial investment cost shown includes the additional cost of design for the solar-energy "add-on" as well as the additional cost of supervision and administration (S&A) anticipated, both considered to be relevant and significant in an application such as this (i.e., one involving an "add-on"). Contingency costs are not included, however, in accordance with standard practice.

b. Computations. The net LCC savings attributable to the solar-energy "add-on" to the conventional DHW system is computed directly by the conventional PW approach applied to the incremental costs of alternative B vs. alternative A (app A). A 10 percent investment credit is applied to the incremental initial investment cost, as required. The annual series equivalence factors are determined from table B-2, with linear interpolation used for the factor for electricity costs. As required by the Congress, the SIR and DPP are also computed (app A). (Note that the worksheet for the SIR and DPP calculations has been designed to be used with either the incremental approach or the tradeoff approach.)

c. Summary. The net LCC savings, SIR, and DPP are reported on the summary sheet DA Form 5605-2-R (Fig A-13). Since the net LCC savings is positive, the solar/electric water heating system must be selected for implementation. (Note that the SIR of 1.5 and the DPP of 13 years also indicate that the solar/electric system is cost effective.)

6-6. Wastewater-treatment facility.

This LCCA–conducted during the early stages of design of a wastewater-treatment facility for Fort Oaks, Alabama-is considered to be responsive to the statutory requirement that all new Federal wastewater treatment facilities make use of innovative or alternative processes and techniques whenever it is not economically prohibitive to do so (i.e., as long as the additional cost of doing so is no more than 15 percent, on an LCC basis). There are four alternatives included in the LCCA, two of which are considered to represent conventional plants (alternatives A and D) and two of which are considered to qualify as innovative/alternative concepts (alternatives B and C). (The alternatives considered–and the basic input cost data—are based largely 'on the guidance provided by the Environmental Protection Agency in EPA Manual 430/9 -78-009.) This LCCA illustrates once again the use of the conventional PW calculation approach. It also illustrates the proper implementation of the special economic ranking criteria of paragraph 2-5 and the proper approach to use when the economic life of the facility is expected to be substantially in excess of 25 years.

a. Input data. The basis input data summary sheets for the four alternatives (app A) reflect the fact that this LCCA, like those described in paragraphs 2-2 and 2-3, is conducted in accordance with the provisions for general economic studies (HQDA criteria). Thus, the discount rate is 10 percent; the mid-year convention is used for annually recurring costs; the timing of all events is natural-i. e., as actually projected; etc. Although the economic lives of the alternatives considered are projected to be well in excess of 25 years-actually, on the order of 40-50 years (on the basis of the best information available at the time the study was conducted) the analysis period is taken to extend only 25 years beyond the BOD, in accordance with the provisions of paragraph 2-2b(3)(b). All costs associated with each of the alternatives are estimated (in large part, as indicated above, based on guidance contained in EPA Manual 430/9-78-009), and then listed on the data summary sheet for that alternative, along with the times they will be incurred, and the sources of cost data, and plotted on the cash flow diagram for that alternative (app A). All relevant and significant costs are provided for, including land acquisition costs, where appropriate (i.e., where land available at the site is inadequate to accommodate the particular alternative, as in the case for alternative D). It should be noted that a methane-gas collection system is incorporated into the design of alternatives A, B, and C, and that this fact is appropriately reflected both in the initial investment costs for these alternatives ($20,000 extra, in each case) and in the annual cost of electricity (reduced by the savings effected through the use of the methane).

b. Computations. The present worths of the various alternatives are computed by the conventional approach, and are entered on the PW worksheets (app A). The annual series equivalence factors were determined on the basis of linear interpolation between tabulated data points in table B-2.

c. *Summary.* The results of the LCCA are summarized on the summary worksheet DA Form 5605.2-R (Fig A-13). Paragraph 2-5c requires that the conventional alternatives be ranked separately, in accordance with the criteria of paragraph 2-2c; that the innovative alternatives be ranked separately, on the basis of their LCCs; and finally that the net LCC of the highest ranked innovative alternative be compared with 115 percent of the net LCC of the highest ranked conventional alternative to determine which of the two will be selected for implementation. Based on these ranking criteria, alternative A is given the higher ranking of the conventional alternatives, and alternative B is given the higher ranking of the innovative alternatives. Since the net LCC of innovative alternative B exceeds 115 percent of the net LCC of conventional alternative A, alternative A is ranked higher and selected for implementation. Note that the unavailability of a substantial amount of extra land at this particular installation at or near the site of the facility has a significant effect on the economic ranking of the alternatives. At another installation, where extra land at the site of interest might be plentiful and readily available, the relative rankings of these same alternatives in all likelihood would be different.